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ORIGINAL

Forest Area Trends in Puerto Rico

Richard A. Birdsey and Peter L. Weaver

SUMMARY

Forest area trends in Puerto Rico from 1980 to 1985 are included in this update of earlier studies. Total forest area has increased from 279,000 ha in 1980 to 300,000 ha in 1985. Most of the new forest is growing on abandoned pasture. Secondary forest and abandoned coffee shade account for 76 percent of all forest land. Xeric scrub and active coffee shade account for 11 percent and 10 percent of all forest land, respectively.

Additional keywords: forest survey, remote sensing, tropical forests.

INTRODUCTION

Puerto Rico's timberland was inventoried in 1980. Detailed statistics on forest area, species composition, and timber volume were reported (Birdsey and Weaver 1982). For the 1980 inventory, forest area estimates were made by a dot-count method using black-and-white aerial photographs taken in the mid-1970's and from field checks in 1980. Forest area estimates for some areas lacking complete photograph coverage were made from other sources of information.

A photographic mission in 1984 provided aerial photographs that were used to develop more current estimates of forest cover, to make reliable estimates for the entire island, and to estimate rates of change in timberland area. Field checks were made in 1985. This report covers area trends between 1980 and 1985.

Fieldwork was accomplished through cooperation between U.S. Forest Service, Southern Forest Experiment Station, and the Puerto Rico Department of Natural Resources. Photography was acquired by the National Aeronautic and Space Administration's Earth Resources Laboratory with support from the Southern Forest Experiment Station.

LONG-TERM FOREST AREA TRENDS

Puerto Rico's 890,000 ha of land were mostly forested in the 16th century. By 1828, timber cutting and development of nonforest land uses had reduced the island's forest cover to about 587,000 ha (Wadsworth 1950). Coffee cultivation under shade trees was just beginning. By 1899 forest cover was reduced to 182,000 ha. Pasture accounted for about 490,000 ha, and coffee production occupied 77,000 ha (Wadsworth 1950). For the next 20 years, tree cover declined slowly (Murphy 1916). The forests could yield few products other than fuelwood or charcoal.

Additional forest clearing began after 1916; by 1931, forests covered only 81,000 ha or 9 percent of the land (Gill 1931). During the late 1940's, forest declined to only 6 percent of the land area, and coffee shade covered about the same area (Koenig 1953). Since then, forests gradually recovered because cropland and pasture were abandoned on eroded hillsides in the island's mountainous regions (fig. 1). By 1980, forests occupied about 250,000 ha and coffee shade about 30,000 ha (Birdsey and Weaver 1982).

METHODS

High-altitude color infrared aerial photography, at a scale of approximately 1:64,000, was acquired for all of Puerto Rico's main island during March, 1984. Cloud cover averaged less than 10 percent. Higher elevations had more cloud cover—especially the Luquillo Mountains in the east and the Toro Negro region in the center of the island.

Prior to fieldwork, an experienced photointerpreter used a dot-count method to identify 12 forest and 3 nonforest land cover classes on film transparencies. (For land cover classes, see DEFINITIONS). A grid of 25 dots

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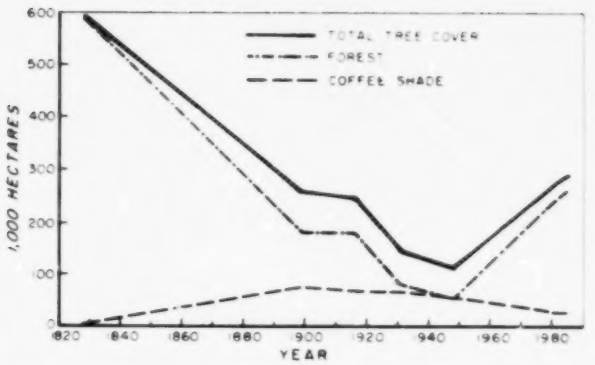

Figure 1.—*Area with tree cover in Puerto Rico, 1828-1985. Forest does not include nonstocked forest land.*

was centered over each of 978 permanent sample plot locations. Sample plots are located at the intersections of a square grid of lines spaced 3 km apart. Land cover class was estimated for each dot and for each plot location. A total of 22,418 dots was interpreted.

Fieldwork was accomplished from January to March, 1985. A subsample of 257 locations was checked to develop a correction factor to account for photointerpretation errors and land use changes between the dates of photo acquisition and fieldwork. The correction factor applied to the dot count adjusted the photointerpretation estimate. Ground check locations were allocated proportional to the 1986 area estimate for each of the land cover classes.

In 1980 about half the Island was identified as potentially capable of commercial forestry and was inventoried intensively (table 1). Remaining areas were excluded from detailed investigation. For this survey, detailed area

Table 1.—*Land area by survey region, Puerto Rico, 1980*

Survey region	Area
	Hectares
Commercial	
Subtropical Moist Forest Life Zone[1]	
Deep volcanic soils[2]	69,000
Shallow volcanic soils	116,700
Granite soils	33,100
Limestone soils	81,100
Total Subtropical Moist Forest Life Zone	299,900
Subtropical Wet Forest Life Zone	
Deep volcanic soils	99,600
Shallow volcanic soils	20,600
Granite soils	12,000
Limestone soils	4,500
Total Subtropical Wet Forest Life Zone	136,700
Total commercial	436,600
Noncommercial[3]	
Subtropical Dry Forest Life Zone	121,500
Critical watersheds	109,300
Unproductive soils	92,200
Alluvial and metropolitan	76,000
Mangrove and swamp	7,500
Noncontinguous Puerto Rico	47,200
Total noncommercial	435,700
Total land area	890,300

[1]Life Zones according to Holdrige (1967), determined by Ewel and Whitmore (1973).
[2]Soil groups defined and mapped by Zambrana (1978).
[3]Areas were defined sequentially in the order presented.

changes were estimated for the commercial forestry region only, and current area estimates were made for the whole Island. In general, the commercial forestry region is located in the central highlands, exclusive of the steepest and wettest areas where forest cover protects critical watersheds (fig. 2). Land areas were classified

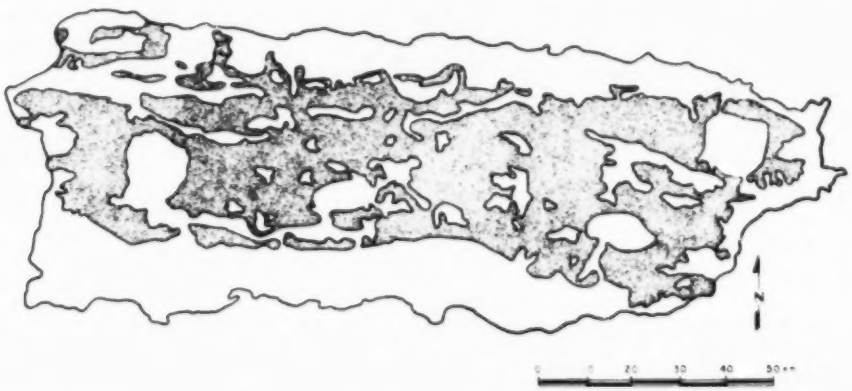

Figure 2.—*The 1980 survey region (in black) judged to be capable of growing commercial timber in Puerto Rico.*

Richard A. Birdsey is research forester, U.S. Forest Service, Southern Forest Experiment Station, Starkville, MS. Peter L. Weaver is research forester, U.S. Forest Service, Southern Forest Experiment Station, Rio Piedras, PR. The authors wish to acknowledge the substantial contributions to this study by the Puerto Rico Department of Natural Resources. Ralph Schmidt provided administrative support, and Luis Vega and Ruben Padron assisted in the fieldwork.

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commercial or noncommercial regardless of ownership.

One of the more challenging tasks was to separate forested tracts from nonforested tracts of land that were reverting from actively grazed pasture to forest. Although the stocking threshold is defined as 10-percent tree cover, active grazing or other nonforest use may cause a tract to be classified as nonforest even if it has more than 10-percent tree cover. In some cases determination can only be based on the judgment of the timber cruiser. In 1985, plot records from 1980 for a few sample locations were reviewed and reclassified. This procedural change does not represent a real change in forest area.

The sampling error for all forest land was estimated to be plus or minus 2.0 percent by random-sampling formula, based on one standard deviation, or a probability of two chances out of three. The sampling error was estimated at 2.6 percent for forests in the commercial survey region, and 1.9 percent for forests in the noncommercial region. As estimates of totals are divided among smaller classes, the sampling error increases.

RESULTS

The estimate of total forest area for the entire Island increased from 279,000 ha in 1980 to 300,000 ha in 1985 (table 2). This increase occurred in the commercial region as reversions of cropland and pasture to forest exceeded forest clearing for nonforest uses (table 3). All new forest land was classified as secondary forest. About 8,000 ha were cleared for relatively permanent nonforest uses such as residences and rights-of-way.

About 58 percent of the Island's forests was classified as secondary, with slightly more than half located in the commercial survey region (table 4). Abandoned coffee shade comprises the next largest forest class. Abandoned and active coffee shade combined total 82,000 ha. The total area of forest that was once used for coffee

Table 2.—*Land area by survey region and broad land cover class, Puerto Rico 1980 and 1985*

1980 survey region and land cover class	Survey date	
	1980	1985
	- *Thousand hectares* -	
Commercial survey region:		
Forest	130.5	160.2
Nonforest	306.1	276.4
Total	436.6	436.6
Noncommercial survey region:[1]		
Forest	148.2	139.3
Nonforest	305.5	314.4
Total	453.7	453.7
All regions:		
Forest	278.7	299.5
Nonforest	611.6	590.8
Total	890.3	890.3

[1]Changes since 1980 may be the result of a more intensive sample and complete aerial photographic coverage of the noncommercial survey region.

Table 3.—*Forest area changes in the commercial survey region, Puerto Rico 1980 to 1985*

Item	Area change	Total area
	------- *Thousand hectares* ------	
Forest area, 1980		130.5
Additions from:		
Cropland	+14.7	
Pasture	+32.2	
Other[1]	+11.7	
Total	+58.6	
Diversions to:		
Cropland	−13.4	
Pasture	−7.4	
Other[2]	−8.2	
Total	−29.0	
Net change	+29.6	
Forest area, 1985		160.2

[1]These additions resulted primarily from a reclassification of some nonforest plots from the 1980 sample and do not represent an actual change in land cover.

[2]Includes forest clearing for urban and industrial development, rural residences, rights-of-way, etc.

Table 4.—*Land area by detailed land cover class and survey region, Puerto Rico 1985*

Land cover class	1985 Survey region		All regions
	Commercial	Noncommercial	
	-------- *Thousand hectares* -------		
Forest:			
Secondary[1]	89.6	83.9	173.5
Abandoned coffee shade	36.5	16.3	52.8
Active coffee shade	22.0	6.8	28.8
Upper mountain	.....	2.3	2.3
Palm	.....	1.8	1.8
Dwarf	.....	1.8	1.8
Xeric scrub	12.1[2]	21.7	33.8
Mangrove	.....	4.7	4.7
Total forest	160.2	139.3	299.5
Nonforest:			
Cropland	40.2	60.3	100.5
Pasture	162.8	146.1	308.9
Other[3]	73.4	108.0	181.4
Total nonforest	276.4	314.4	590.8
All land	436.6	453.7	890.3

[1]Also includes nonstocked forest land, plantations, and lower mountain (tabonuco) types.

[2]Xeric forest cover on limestone and serpentine soils formerly classified as secondary forest.

[3]Idle farmland, water, roads and rights-of-way, urban, and industrial areas.

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production is more than 82,000 ha, but older abandoned coffee shade becomes difficult to distinguish from reverted pasture or cropland.

Another common cover class is xeric scrub, accounting for 11 percent of Puerto Rico's forest. Most of this vegetation is located along the southern coast, which receives less than 1,000 mm of rainfall annually. The remainder is scattered elsewhere on limestone or serpentine soils that are highly permeable or on extreme slopes that hold very little soil. These conditions produce scrub vegetation despite adequate rainfall.

Although other forest classes occupy small areas, they are nevertheless very important as protective forests for upper watersheds, coastal lowlands, and wildlife habitat. Some of these small areas are the last refuge of endangered plant and wildlife species. Plantation and lower mountain forests, not sampled intensively enough to provide separate area estimates, were included in the secondary forest class.

CONCLUSIONS

Between 1980 and 1985, Puerto Rico's forest area increased by about 4,000 ha annually. Puerto Rico's forest resource is approaching a stage of recovery that could support sustained removals of useful timber products from selected areas.

A review of the 1980 survey by Wadsworth and Birdsey (1985) concluded that about half the secondary forest was adequately stocked with species that have good timber potential. As the area of adequately stocked timberland increases, so too will the opportunity to develop silvicultural methods to enhance the value of timber stands. The new forests also are valued for recreation and watershed protection. The increase in forest area may provide many benefits to the residents of Puerto Rico.

DEFINITIONS

Land Class

Nonforest Land.—Land not meeting the qualifications for forest land, land that has never supported forest, and lands formerly forested where timber management is precluded by development for other uses. Includes areas used for crops, improved pasture, residential areas, improved roads of any width adjoining clearings, and powerline clearings.

Forest Land.—Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for nonforest use. The minimum area for classification of forest land is 1/2 ha, and minimum width for forest strips is 35 m. Includes unimproved roads and trails, streams, and clearings in forest areas if less than 35 m in width.

Forest Class

Mangrove.—Inundated forest formations along the shores of protected saline bays, lagoons, and estuaries.

Nonstocked Forest Land.—Forest land less than 10 percent stocked with growing-stock trees or formerly having such tree cover and not currently developed for nonforest use. Areas covered by inhibiting vegetation such as brush, vines, and ferns may be included.

Reversion.—Pasture or cropland with 10 to 50 percent tree and shrub crown closure or stocking.

Secondary Forest Land.—Forest land resulting from the abandonment of cropland or pasture and forest resulting from the regeneration of previously cutover or disturbed forest land.

Coffee Shade.—A multistory, multicrop system used principally for the production of coffee. An upper story of shade trees is characteristic.

Abandoned Coffee Shade.—Secondary forest land resulting from the abandonment of coffee production under shade trees.

Lower Mountain Forest.—The local "tabonuco" forest type, with *Dacryodes excelsa* usually, but not necessarily, dominant. Found in the Subtropical Wet Forest Life Zone. Common associate species are *Sloanea berteriana*, *Prestoea montana*, and *Manilkara bidentata*.

Upper Mountain Forest.—The local "colorado" forest type, with *Cyrilla racemiflora* usually, but not necessarily, dominant. Found in the Subtropical Lower Montane Wet Forest Life Zone. Common associate species are *Ocotea spathulata*, *Micropholis chrysophylloides*, and *M. garciniaefolia*. *Prestoea montana* is common in the central mountains.

Palm Brake.—Nearly pure stands of *Prestoea montana* that form in upper mountain regions.

Dwarf Forest.—Also known as cloud forest or elfin woodland. Found on the summits of the highest mountains and characterized by densely packed, gnarled trees less than 7 m tall.

Plantation.—Stands in which artificially regenerated species comprise more than 25 percent of the total basal area.

Xeric Scrub.—Small woody vegetation generally less than 10 m tall at maturity, found under dry conditions typical of the Subtropical Dry Forest Life Zone and on certain serpentine and limestone soils.

Survey Region

Commercial.—Land judged capable of growing commercial timber crops. Includes all areas that were not excluded because of low rainfall, excessive rainfall, excessive slope, unproductive soil, or higher priority use such as prime farmland or urban development. Also excludes mangrove and swamp areas and all islands not connected to the mainland.

Noncommercial.—All areas excluded from commercial timber production (see definition of commercial region).

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